Expert consensus regarding drivers of antimicrobial stewardship in companion animal veterinary practice: a Delphi Study

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Abstract

Antimicrobial resistance (AMR) is a global challenge facing both human and animal healthcare professionals; an effective response to this threat requires a 'One-Health' approach to antimicrobial stewardship (AMS) to preserve important antibiotics for urgent clinical need. However, understanding of barriers and enablers to effective antimicrobial stewardship behaviour in companion animal veterinary practice is currently limited.

We conducted a Delphi Study of 16 nationally recognised experts from UK based veterinary policy makers, university academics, and leaders of professional bodies. This Delphi study sought to identify veterinary behaviours which experts believe contribute to AMR and form vital aspects of AMS. Analysis of Delphi findings indicated a perceived hierarchy of behaviours, the most influential being antibiotic prescribing behaviours and interactions with clients. Other veterinary behaviours perceived as being important related to interactions with veterinary colleagues; infection control practices; and the use of diagnostic tests to confirm infection. Key barriers and enablers to AMS within each of these behavioural domains were identified. Specific interventions to address important barriers and enablers are recommended.

To the authors' knowledge, this is the first study to establish expert consensus at a national level about which 'behaviours' (aspects of veterinarian practice) should be targeted in relation to antimicrobial resistance and stewardship in companion animal veterinary practice.

Introduction (word limit 4,000 words in text, exl tables & refs; at 3,800)

The World Health Organisation (WHO) has declared that antimicrobial resistance (AMR) is "a problem so serious that it threatens the achievements of modern medicine. A post-antibiotic era - in which common infections and minor injuries can kill - far from being an apocalyptic fantasy, is instead a very real possibility for the 21st century" (World Health Organisation 2014) p.ix. This view was endorsed by the UK O'Neill Report (O'Neill 2016) p.1, which stated "tackling AMR is absolutely essential. It needs to be seen as the economic and security threat that it is". The objectives of the O'Neill Report highlight the need for antimicrobial stewardship in both human and animal health. AMR is a true one-health problem that encompasses all species and does not recognise boundaries between humans, animals and our shared environment. There is close contact and microbial exchange in animal owning households, (Westgarth and others 2008; Damborg and others 2016). Similarly, there is evidence of AMR in the food chain (Bengtsson and Greko 2014) and in the environment (Cinquepalmi and others 2013). Antimicrobial drugs used in animals and humans, if not identical, are very similar (Commitee for Medicinal Products for Veterinary Use (CVMP) 2013). More specifically, AMR bacteria in animals and humans are closely related (Guardabassi and others 2004; Pomba and others 2017) and the AMR genes are identical (Catry and others 2010).

In response to the threat of AMR a number of national and international guidelines for antimicrobial stewardship (AMS) and responsible use in companion animal practice have been developed. The recent Guidance for the Rationale Use of Antimicrobials (GRAM) (Brissot and others 2016) are probably the most comprehensive but others include those by the International Society of

Companion Animal Infectious Diseases (ISCAID 2017), Federation of European Companion Animal Veterinary Associations (FECAVA 2017), British Veterinary Association (BVA 2017) and the British Small Animal Veterinary Association (BSAVA 2017) as well as national guidelines in Denmark and Sweden (the guidelines and recommendations are summarised in Brissot and others 2016). The scope and content of these vary and implementation varies from mandatory (e.g. in Sweden) to professional responsibility (e.g. in the UK) or voluntary. There is evidence of inappropriate antimicrobial prescribing by veterinarians in the UK (Hughes and others 2012 ; Buckland and others 2016), which may be related to inconsistent use of guidelines and other sources of advice. In a UK survey from 2009 only 3.5% of 473 respondents reported that their veterinary practice had antimicrobial use guidelines (Hughes and others 2012). However, a more recent survey from 2014 reported that 45% of practices had antimicrobial use guidelines and 92.4% of the respondents were aware of available guidelines (Lloyd and others 2016). Despite this apparent shift, available evidence indicates that veterinarians appear to have limited awareness of current recommendations for responsible antimicrobial use and antimicrobial choices can be influenced by social norms (Mateus and others 2014). Of particular concern are Buckland and others (2016) findings of a high frequency antimicrobial use in companion animal veterinary practice, including those antimicrobials classified as of 'critical importance' for human medicine. Buckland and others (2016) also note that limited reliable evidence is available on the extent of antimicrobial use in companion animals and highlight the potential value of electronic health records in veterinary practice for studying antimicrobial use.

Developing interventions to enhance antimicrobial stewardship by companion animal veterinarians is embedded in the five-year UK Governmental Action Plans for AMR (Department of Health 2013). The Scottish Government and National Health Service (NHS) Health Protection Scotland (HPS) established the 'Controlling Antimicrobial Resistance in Scotland' (CARS) group. This group was tasked with developing a One-Health model of best practice antimicrobial stewardship in conjunction with the pre-existing clinical Scottish Antimicrobial Prescribing Group (SAPG). The CARS work encompasses medical and veterinary healthcare, the general public, animal owners, agriculture, the pharmaceutical industry, and the environment. CARS commissioned a series of research studies to inform the development of evidence-based and theoretically informed behavioural interventions to enhance companion animal veterinary antimicrobial stewardship (The AMR-PET-VET Project) among vets and pet owners. The first of these, reported here, was to develop an understanding of expert consensus regarding the behavioural drivers of antimicrobial stewardship in companion animal veterinary practice.

Research questions:

1. What do experts believe are the most important companion animal veterinary behaviours that need to change in relation to AMR and AMS?
2. What do experts believe are the key modifiable barriers and enablers associated with implementing interventions designed to change the behaviours identified above?

Method:

Due to the complexity of AMR and the limited existing evidence base on companion animal antimicrobial stewardship, expert consensus was sought to identify key 'behavioural domains' (i.e. 'broad categories of usually interrelated behaviours which are linked by similarity of contexts and

actors') and their 'constitutive behaviours' that could be targeted by future behaviour change interventions to enhance stewardship.

A Delphi Survey approach was adopted to scope expert knowledge and opinions. Originating in 1948, Delphi methods are a well-recognised technique for "obtaining expert opinion in a systematic manner" (Fink and others 1991, p. 1) by adopting an iterative, multi-stage, inductive process which moves from individual opinion to generating group consensus (Hasson and others 2000). Hsu & Sanford (2007, p. 1) contend that "it is a widely used and accepted method for achieving convergence of opinion concerning real-world knowledge solicited from experts within certain topic areas." The Delphi approach has been used to develop consensus around research agendas and to drive these forward in relation to range of topics, such as; reducing the morbidity associated with infections in surgical patients (Nathens and others 2006), defining good practice in relation to animal welfare change (Messori and others 2016), and as part of an evaluation of a programme related to the prevention of healthcare-associated infections and AMR (Carlet, 2009). Recent work by Khodyakov and others (2016) demonstrates that a modified on-line Delphi survey is an acceptable method to participating experts and stakeholders. 'Expert' is defined here in relationship to professional expertise among veterinary policy makers, university academics, and leaders of professional bodies. The study was approved by the Glasgow Caledonian University Ethics Committee (HLS id: HLS/NCH/16/001). An on-line Delphi survey was conducted in two rounds, as described in the data collection sections below. Consecutive rounds of the Delphi survey reported back collated data to the expert participants, asking them to respond to the ideas produced by themselves and others, ultimately resulting in a rank ordered list of views generated by the entire group.

Data collection

The Delphi study was conducted in three consecutive stages:

- Stage 1 - Exploring the range of expert beliefs in relation to the behavioural drivers of AMR and AMR stewardship.
- Stage 2 - Exploring priorities for behaviour change as determined by experts.
- Stage 3 – Integrating and interpreting findings in relation to the primary research questions.

Stage 1- Exploring the range of expert beliefs in relation to the behavioural drivers of AMR and AMR stewardship

The CARS Project Advisory Group nominated 20 potential Delphi survey participants from UK based veterinary experts in government policy units, universities, and professional organisations. Following consultation and piloting with the Advisory Group, the first round of Delphi questions (see Table 1) were circulated via an email SurveyMonkey© link in November 2016. Each question comprised of an open text box for responses, enabling participants to enter as many or as few ideas as they wished. We used the phrase 'aspects of practice' in preference to 'behavioural drivers' during data collection as it was thought this would be more familiar to respondents, thereby generating more spontaneous ideas.

Table 1: First round Delphi survey questions

1. What aspects of companion animal veterinary practice do you think may contribute to antimicrobial resistance? 2. What aspects of companion animal veterinary practice do you think may contribute to effective antimicrobial stewardship? 3. What aspects of the relationship between companion animal veterinarians and pet owners do you think may affect antimicrobial stewardship behaviours? 4. Which of the above aspects of antibiotic stewardship do you think are important to target as a priority for practice change by veterinarians? 5. An open text box for any further points about antimicrobial stewardship in the context of companion animal veterinary practice.

Stage 1 Results

Eighteen participants completed the first round survey, generating 39 to 75 individual suggestions for each question. Principles of content analysis (Elo and Kyngäs 2008) were applied to categorise responses by frequency to generate a list of the most important suggestions for each question raised by the expert participants. Two researchers confirmed the analysis to enhance rigour.

Stage 2- Exploring priorities for behavioural change as determined by experts

The categories elicited in Stage 1 were used to design the Stage 2 survey questions (Table 2), which were entered onto a SurveyMonkey© questionnaire with Likert style response options and associated scores for questions 1-4, as follows: Strongly disagree (-2); disagree (-1); neither agree nor disagree (0); agree (+1); strongly agree (+2). Question 5 asked participants to place items in rank order of importance.

The Stage 2 survey was circulated to all initial participants in December 2016 with 16 participants responding. SurveyMonkey© enables an automatic weighted average score to be generated per question (i.e. responses per item [-2 to +2] are summed then divided by the number of respondents). The weighted average scores are then reported in rank order, with highest score first. Weighted average scores approaching +2 indicate stronger agreement with the item within the group; scores tending towards -2 indicate stronger disagreement with the item within the group; scores around 0 indicate predominantly neutral or dispersed views within the group.

Table 2: 2nd round Delphi survey questions

1. To what extent do you agree that each of the following aspects of companion animal veterinary practice is important in contributing to antimicrobial resistance (AMR)? 2. To what extent do you agree that each of the following aspects of companion animal veterinary practice is important in contributing to effective antimicrobial stewardship behaviours? 3. To what extent do you agree that the following aspects of the relationship between companion animal veterinarians and pet owners are important in affecting the veterinarian's antimicrobial stewardship behaviours? 4. To what extent do you agree that the following aspects of antimicrobial stewardship should be priorities for behaviour change interventions targeted towards companion animal veterinarians? 5. Please use the drop down menu tab to place the following targets for behaviour change

interventions to improve antimicrobial stewardship in rank order of importance, where 1=most important and 8=least important.

6. An open text box for any further points about maximising antimicrobial stewardship in companion animal veterinary practice

Stage 2 Results:

The responses to each Stage 2 question were analysed and placed in rank order as described above (see Tables 3-7). These results form the basis of the integration of all data sets presented in Stage 3.

Table 3: Expert consensus regarding key aspects of companion animal veterinary practice that are important in contributing to antimicrobial *resistance*

Question item:	Weighted Average	Rank Order of agreement
• Poor choice of antimicrobial e.g. critically important antimicrobial as first line; over-reliance on broad spectrum antimicrobials	1.25	1
• Unnecessary antimicrobial prescription 'just in case'	1.25	1
• Lack of use of diagnostic tools such as culture & sensitivity testing	1.00	3
• Client's expectations to have antimicrobials prescribed	1.00	3
• Unnecessary prophylactic use of antimicrobials around surgery	0.94	5
• Peer pressure among younger veterinarians to comply with practice norms	0.81	6
• Poor pet owner compliance to the prescription when using antimicrobials	0.81	6
• Lack of knowledge/understanding amongst veterinarians of AMR related issues	0.75	8
• Lack of evidence-based agreement about AMR contributory factors	0.63	9
• Contact and transmission of resistant organisms between pets & owners	0.38	10
• Uncertainty about dose/duration of antimicrobial (i.e. over or under prescribing)	0.06	11
• Poor infection control procedures in veterinary practices	0.00	Neutral
• Pharma company pressures on veterinarians to sell antimicrobials	-0.31	Disagree

The expert responses to factors which contribute to resistance (table 3) indicate relatively strong agreement that inappropriate prescribing behaviours (weighted average 1.25) are most important in contributing to antimicrobial resistance. Overall, aspects of prescribing and use appear in four of 13 ranked items for this question. Poor use of diagnostic tools and beliefs that clients expect antimicrobials were the next most influential factors (weighted average 1.00), followed by veterinary knowledge and understanding of AMR (weighted averages 0.63-075). Factors associated with infection control and zoonotic transmission tended toward neutral (weight averages 0-0.38). The

experts surveyed disagreed (weighted average -0.31) that pharmaceutical pressures to sell antimicrobials leads to antimicrobial resistance.

Table 4: Expert consensus regarding key aspects companion animal veterinary practice is important in contributing to antimicrobial *stewardship*

Question item:	**Weighted Average**	**Rank Order of agreement**
• Consistently applying optimal prescribing practice (e.g. correct dosing of most appropriate antibiotic only when essential and clinically indicated for identified infection; avoiding broad-spectrum antibiotics; reducing prophylactic use)	1.56	**1**
• Effective communication between veterinarians and clients around appropriate use of antimicrobials	1.44	**2**
• Accessible veterinary training & Continuing Professional Development (e.g. free, on-line provision)	1.44	**2**
• Working in a culture of adherence to recognised professional guidelines in practice-based teams	1.25	**4**
• Good infection control processes in use in the practice setting	1.19	**5**
• Greater use by veterinarians of available diagnostic testing for culture & sensitivity	1.13	**6**
• The commercial context of veterinary practice (i.e. veterinarian is reliant on continued pet-owner custom) may impede effective antimicrobial stewardship	0.63	**7**
• Professional regulation of prescribing practice (RCVS & PSS)	0.47	**8**

***(RCVS – Royal College of Veterinary Surgeons; PSS – Practice Standards Scheme)**

Expert consensus in relation to *stewardship* (table 4) shows that prescribing behaviours (classified as '*optimum*') were thought to be most important in antimicrobial stewardship (weighted average 1.56). Related to this was working in a culture of optimum practice (weighted average 1.25). Other factors with strong agreement included the veterinarian's relationship and communication with clients, and available and effective training (weighted averages 1.44). In comparison to question 1 (table 3), experts were less agreed on whether using diagnostic testing contributed to antimicrobial stewardship (weighted average 1.13; rank 6th). The least influential items were commercial pressures linked to client custom (weighted average 0.63) and regulation of veterinary prescribing (weighted average 0.47).

Thus, the two key behavioural domains that the experts felt were highly influential in regard to antimicrobial resistance and stewardship, illustrated in tables 3 and 4, were 1) prescribing behaviours and 2) the veterinarian's interactions with clients.

Table 5: Expert consensus regarding key aspects of the relationship between companion animal veterinarians and pet owners that affect the veterinarian's antimicrobial stewardship

Question item:	Weighted Average	Rank Order of agreement
• Defensive veterinary practice to keep owners happy or minimise risk; prescribing 'just in case'	1.31	**1**
• Veterinarian-client communication to increase client awareness of antimicrobial resistance	1.31	**1**
• A trusting relationship where the client accepts advice not to use antimicrobials	1.25	**3**
•Time pressures on veterinarians during consultations reduce opportunities for client education (i.e. it is quicker to prescribe than discuss appropriate antimicrobial use)	1.19	**4**
• Veterinarians believe that clients may think diagnostic tests are too expensive or too time consuming	0.88	**5**
•Veterinarians feel a pressure to prescribe antibiotics to meet client expectations	0.87	**6**
• Veterinarians believe clients may go elsewhere to get an antibiotic	0.19	**7**

Table 5 illustrates the barriers and enablers to AMR stewardship in the context of the relationship between companion animal veterinarians and pet owners. Veterinarian's beliefs about their clients and the likelihood of infection ('*defensive veterinary practice*', '*keep owners happy'* or '*just in case'*) shared top ranking with a complementary yet distinct view ('*the importance of veterinary-client communication to increase client awareness of AMR*') (weighted averages 1.31). Trusting relationships enabling the client to accept advice was also seen as an important enabler (weight average 1.25), while time pressure was widely accepted barrier to stewardship (weighted average 1.19). Veterinarian's beliefs around client expectations (diagnostic tests are too expensive; antibiotics are expected; and clients will go to another veterinarian for antibiotics) generated lower levels of agreement among our experts, occupying the bottom three ranks for this question.

Table 6: Expert consensus regarding priorities for behaviour change interventions targeted towards companion animal veterinarians

Question item:	Weighted Average–	Rank Order of agreement
• Clear national guidelines and decision-support tools for veterinary practice	1.56	1
• Practice level antimicrobial policies in place	1.38	2
• Local (or national) clinical audits of antimicrobial usage with feedback to veterinarians	1.13	3
• Accessible (e.g. free, on-line) AMR related training & education for veterinarians	1.06	4

• Promote the use of diagnostic sensitivity testing	1.06	4
• Help for veterinarians to manage client expectations	1.00	6
• Mass media campaign approach to client & public education on AMR in pets	0.44	7
• Limitations on veterinary prescribing of certain antimicrobials	-0.06	Disagree

Table 7: Expert consensus regarding targets for behaviour change interventions to improve antimicrobial stewardship (in rank order of importance, where 1=most important and 8=least important).

Question item:	**Rank order**
• Clear national guidelines and decision-support tools for veterinary practice	**1**
• Practice level policies in place	**2**
• Accessible (e.g. free, on-line) AMR related CPD for veterinarians	**3**
• Promote the use of diagnostic sensitivity testing	**4**
• Local (or national) clinical audits of antimicrobial usage	**5**
• Help for veterinarians to manage client expectations	**6**
• Mass media campaign approach to client / public education on AMR in pets	**7**
• Limitations on veterinary prescribing of certain antimicrobials	**8**

The findings from table 6 (extent of agreement) and table 7 (rank ordered priorities) look at potential interventions to change behaviour about antimicrobial stewardship. The findings are not mutually exclusive and show a series of priorities. The expert participants ranked 'clear national guidelines and decision-support tools for veterinary practice' first (weighted average 1.56), which is linked to implementing practice level policies (weighted average 1.38). These factors would also encompass or influence the following other items on education, diagnostic testing, audit, and communication. However, the experts did not agree (weighted average -0.06) that there should be restrictions on veterinary prescribing of certain antimicrobials.

Stage 3: Integrating and interpreting findings in relation to primary research questions

The study findings were integrated using a behavioural framework approach to highlight which behaviours need to be changed (in this case, to enhance antimicrobial stewardship) and what is likely to change these behaviours (antecedents in the shape of barriers and facilitators). This approach is useful to provide ideas to help target future behaviour change interventions most effectively.

What do experts believe are the key barriers and enablers to changing antimicrobial stewardship behaviours?

Findings from the various Delphi questions integrated into a rank ordered hierarchy of behavioural domains. *'Prescribing behaviours'* emerged as the most important focus to change behaviour around AMR and AMS. This domain encompasses a range of component behaviours that all reflect

inappropriate and diverse prescribing practice and behaviours. This is related to the next highest ranked behavioural domain (*'interactions with clients'*), where veterinarian's perceptions of client expectations drive inappropriate prescribing. Similarly, in *'interactions with professional practice colleagues',* senior veterinary colleagues and wider practice norms could shape poor stewardship behaviour. In addition, in *'approach to diagnosing infection'* limited implementation of diagnostic testing is influenced by perceived client expectations, commercial pressures, and peer pressures within the practice, and can lead to inappropriate prescribing and stewardship behaviours. The only veterinary behaviours not directly associated with antibiotic use but potentially influential in reducing AMR were *'infection control procedures'*, although this was ranked last out of the behaviours to change.

Using the data from across the Delphi questions, Table 8 maps the relationship between the key behaviours driving inappropriate antimicrobial prescribing and stewardship with the factors that lead to them (i.e. the barriers and facilitators to appropriate antimicrobial prescribing and stewardship). This illustrates the expert consensus on the most important behaviours to change and factors that assist or hinder better antimicrobial stewardship. For example, the experts believed that better prescribing can be shaped by local (or national) clinical audits of antimicrobial usage with feedback to veterinarians (a key facilitator of better prescribing) and through reducing unnecessary prophylactic use of antimicrobials around surgery (a key barrier to better prescribing).

Table 8: Expert consensus regarding the relative importance of barriers and enablers for AMS (the numbers in brackets indicate levels of agreement between the experts, with scores between 1- 2 indicating higher levels of agreement)

Rank Order of Importance of Veterinary Behavioural domains	Key Barriers	Key Enablers
Appropriate Prescribing (1.56)	Poor choice of antimicrobial (1.25)	Clear national guidelines and decision-support tools for veterinary practice (1.56)
	Unnecessary antimicrobial prescription 'just in case' (1.25)	Consistently applying optimal prescribing practice (1.56)
	Unnecessary prophylactic use of antimicrobials around surgery (0.94)	Local (or national) clinical audits of antimicrobial usage with feedback to veterinarians (1.13)
	Lack of knowledge/understanding amongst veterinarians of AMR related issues (0.75)	Accessible (e.g. free, on-line) AMR related training / education for veterinarians (1.06)
	Lack of evidence-based agreement about AMR contributory factors (0.63)	Professional regulation of prescribing practice (RCVS/PSS)* (0.47)
	Uncertainty about dose/ duration of antimicrobial (0.06)	
Interactions with clients (1.44)	Defensive veterinary practice to keep owners happy or minimise risk; prescribing 'just in case' (1.31)	Effective communication between veterinarians and clients around appropriate use of antimicrobials (1.44)
	Time pressures on veterinarians during consultations reduce opportunities for client education i.e. it is quicker to prescribe than discuss appropriate antimicrobial use (1.19)	A trusting relationship where the client accepts advice not to use antimicrobials (1.25)
	Client's expectations to have antimicrobials prescribed (1.00)	Help for veterinarians to manage client expectations (1.00)
	Veterinarians believe that clients may think diagnostic tests are too expensive or too time consuming (0.88)	Mass media campaign approach to client / public education on AMR in pets (0.44)
	Veterinarians feel a pressure to prescribe	

	antibiotics to meet client expectations (0.87)	
	The commercial context of veterinary practice (i.e. veterinary is reliant on continued pet-owner custom) (0.63)	
	Veterinarians believe clients may go elsewhere to get an antibiotic (0.19)	
Interactions with Veterinary colleagues (1.38)	Peer pressure among younger veterinarians to comply with practice norms (0.81)	Practice level antimicrobial policies in place (1.38)
		Working in a culture of adherence to recognised professional guidelines in practice-based teams (1.25)
Infection control practices (1.19)	Poor infection control procedures in veterinary practices (0.00)	Good infection control processes in use in the practice setting (1.19)
		Greater use by veterinarians of available diagnostic testing for culture & sensitivity (1.13)
Use of diagnostics to confirm infection (1.13)	Lack of use of diagnostic tools such as culture & sensitivity testing (1.00)	Promote the use of diagnostic sensitivity testing (1.06)

*(RCVS-Royal College of Veterinary Surgeons; PSS-Practice Standards Scheme)

Discussion

To the authors' knowledge, this is the first study to establish expert consensus at a national level about which behaviours should be targeted in relation to antimicrobial resistance and stewardship in companion animal veterinary practice. It is also the first to detail expert perceptions of the key barriers and facilitators to such stewardship behaviours. The following discussion explores each behavioural domain in turn.

Prescribing behaviours

Prescribing behaviours were understood as the most important behaviours to change, as perceived by the participating experts. There was most support for enablers to responsible prescribing that focus on increased antimicrobial governance, including: national guidance; decision-support tools; and audits with feedback on individual and practice antimicrobial use. These enablers address the perceived barriers of poor choice and unnecessary use of antimicrobials. In turn, these issues were perceived to be associated with lack of knowledge and understanding of the aetiology of AMR that could be ameliorated by accessible AMR-related training and education. The analysis suggests that effective interventions should focus on change of prescribing behaviours (e.g. by increasing awareness and engagement with authoritative guidelines, and educating veterinarians about the consequences of inappropriate prescribing). Previous studies have shown that UK veterinarians have a low uptake of antimicrobial use guidelines, limited awareness of their details, and are prone to social norms and verbally agreed practice protocols (Hughes and others 2012 ; Mateus and others 2014). However, there is a high level of awareness about guidelines, which are widely available in print, web-based and other formats, and through local, national and international CPD. In a systematic review of nurse prescribers' antibiotic prescribing behaviours, evidence indicates that, as their prescribing education is largely protocol driven, nurses are likely to base their practice on available national guidelines and local protocols, suggesting that these decision support tools can be valuable in influencing prescriber behaviour (Ness and others 2016). The challenge for veterinarians is therefore to facilitate and improve engagement and adherence with available guidance.

Results from a cross sectional survey of 473 veterinarians (Hughes and others 2012) and findings from in-depth qualitative interviews with 21 veterinarians (Mateus and others 2014) both demonstrate that discussion of clinical cases with peers and effectiveness meetings in the workplace are clearly valued ways for veterinarians to learn and share knowledge, allowing discussion and agreement on protocols for clinical conditions and surgical procedures. However, these should be evidence-based, follow current recommendations and take into account the resources available in the workplace. Targeted training of veterinarians in the workplace with peer support around compliance with guidelines should be used to promote responsible antimicrobial usage.

Interactions with clients

Within this domain, key enablers proposed by expert participants were effective communication between veterinarians and clients around the appropriate use of antibiotics, a trusting relationship, help for veterinarians to manage client expectations, and wider public education around AMR in pets. Key barriers were perceived by experts to be the veterinarian's belief that their clients both expected and wanted antibiotics, and would go elsewhere if they were not prescribed to them, as well as lack of sufficient time in a consultation for client education. Comparable perceptions regarding the pressure of patient expectations to be given an antibiotic are reported in the literature

exploring medical doctors and registered nurses' prescribing behaviours (Ness and others 2016), with a survey of 1,000 UK General Practitioners reporting that 90% felt pressure from patients to prescribe antibiotics (Nesta, 2014). Whilst the concerns raised by our expert participants may be credible risks in the context of small business veterinary practices, the commonality of these perceptions across animal and human health prescribers suggests that interventions should focus upon social influence and address veterinarian's beliefs about their client's expectations and the consequences of their stewardship behaviour (i.e. challenging the belief that clients will go elsewhere for antimicrobials). Pet owners have high expectations from their veterinarians, and a study in Norway and Iceland found that one-third of clients reported problems with lack of trust and poor communication with their veterinarians (Lund and others 2009). Unlike the context of antibiotic prescribing in UK-based human health, issues about cost may also influence diagnostic and treatment choices. A US study found that veterinarians and pet owners differed in the way they discussed treatment and costs; veterinarians focused on tangibles (e.g. time and services) and pet owners focused on health outcomes with some suspicion of the motivation behind veterinarians recommendations (Coe and others 2007).

Veterinarians should be trained and supported in communication and managing client expectations around antimicrobial use. However, there are real time constraints within a consultation, and effective communication would be helped by high quality public education and awareness interventions about antimicrobial stewardship and resistance in pets, as well as humans. Interventions should embrace and acknowledge the professional and social roles of both veterinarian and client and the different factors that shape each of their behaviours. These could include targeted and mass media interventions at practice, local and national levels to mirror those in human healthcare. Endorsing this recommendation, a recent systematic review examining education programmes for prescribers and the public (Chang-Ro Lee and others 2015) found some successful campaigns directed at the general population have led to a substantial reduction in prescribing and that that multifaceted interventions involving both physicians and the public/patients (through written material and mass media) seem moderately more effective than single interventions, in decreasing unnecessary antibiotic use. This approach would have the added benefit of contributing to cultural and behavioural change in the One-Health context, as companion animal owners (who are also potentially patients or carers of patients) will then receive consistent messages from prescribers in both animal and human healthcare environments.

Interactions with veterinary colleagues, infection prevention and control practices and the use of diagnostics to confirm infection

Expert participants proposed several shared enablers across these behavioural domains including social influence and norms within practice settings, and changes to the culture of the profession. Equally, there were perceived barriers to stewardship related to practice norms, including interactions with more senior colleagues or poor infection control procedures. Analysis of the key barriers and enablers identified by experts in this Delphi study supports previous research findings that highlighted the significance of social influences on veterinary stewardship behaviours (Hughes and others 2012 ; Mateus and others 2014). Changing cultures within an organizational context is challenging, particularly when that context reflects a professional business enterprise. Shifting practice norms will need a range of creative approaches, which could include group education, changes to professional regulation, and, potentially, individual or practice incentives to reward

intended behaviours. The latter need not be financial, and could involve recognition similar to the Royal College of Veterinary Surgeons Practice Standards Scheme accreditation.

Arguably, the effective implementation of national guidelines, translated into local practice policies, would address all key aspects of veterinary practice related to antimicrobial stewardship. This would also provide an 'independent' external referent point for veterinarians to have conversations with clients regarding appropriate antimicrobial use. It would also provide a baseline of expected standards in what is, in effect, a competitive small business environment.

This report may be considered limited by focusing on the perceptions of participating experts, rather than the views of veterinarians and pet owners. Further studies exploring the views, expectations and experiences of practising veterinarians and pet owners are ongoing. Harnessing all the data from these groups will help further define effective intervention strategies to improve antimicrobial stewardship at all levels in companion animal practice.

Conclusions

Data generated through this Delphi study have found a wide range of factors that may influence antimicrobial stewardship among companion animal veterinarians. The Delphi approach is a commonly used approach to assess expert opinion (Fink and others 1991), although is not without its critics (Sackman 1974). Consecutive stages of the Delphi process established expert consensus on a hierarchy of three key behavioural domains with associated constituent behaviours. The most important was veterinary prescribing, followed by interactions with clients, and then social norms within the practice setting (including interactions with other veterinarians, use of diagnostic tests and infection control practices). Stewardship behaviours may be influenced by minimising key barriers and maximising enablers in practice. Identifying important behavioural domains and the barriers and enablers to intended veterinary behaviour helps identify interventions that are likely to be effective.

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